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THEODORE ROOSEVELT (CVN 71)
CONSTRUCTION SCHEDULE COMPRESSION

SNAME SHIP PRODUCTION COMMITTEE
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Introduction

The shipbuilding industry has made significant advances in its use of modernized ship construction techniques and facilities. I am certain that many of the papers being presented at this Symposium will describe those techniques and address the technical advantages that accrue from their use. This paper, in addition to discussing those topics, attempts to examine the environment in which improvements in ship construction can occur and looks at the type of planning that must be done to ensure benefits are realized. The Navy is now the major customer of the U.S. shipbuilding industry, and even with the increased emphasis on competitive procurement, by necessity, contracts for a significant amount of sole source ship construction will exist due to technical or facility constraints. For these contracts, as well as many others, the shipbuilder has a limited incentive to accept the increases in risk inherent in changing his business strategy and existing industrial processes. The Navy has recognized this problem and I will now attempt to describe the successful effort to change this environment for aircraft carrier construction.

Program Background

In 1979 the Navy started the detail planning for the acquisition of THEODORE ROOSEVELT (CVN 71), which is the fourth ship of

the NIMITZ class of nuclear aircraft carriers. Since CVN 71 was a repeat design, the planned and actual construction schedules for the earlier ships were closely examined to determine if improvements were possible and, if so, what steps should be taken to ensure that an optimum schedule was achieved. An optimum schedule, in this instance, is one that achieves the earliest possible ship delivery at the lowest possible cost to the taxpayer. This would ensure minimum escalation and "parking" or facility cost and should result in significant total cost savings. In addition to the direct monetary saving which might be realized by this optimized schedule, improved shipbuilder performance would enhance the opportunity for renewed public support of the defense expenditures that were being advocated for major Navy programs in the 1980's. Earlier delivery of CVN 71 would also be very important strategically, providing for a more rapid counter to the Soviet naval buildup, quicker reconstitution of U.S. military presence around the world, additional flexibility in the overhaul and refueling of existing carriers, and earlier availability of improved ship construction resources at Newport News Shipbuilding (NNS). The plans for a Ship Life Extension Program (SLEP) on CV 59 class carriers would also be enhanced by the availability of CVN 71 since the need for a Navy presence in the Indian Ocean was severely straining our strength in the western Pacific.

Prior Schedule Experience

At this time it was recognized that, from a contractual standpoint, achieving the optimized schedule would be difficult since NNS was the sole source shipyard for NIMITZ class carriers and its prior experience would tend to make them conservative unless suitable incentives could be provided. That experience (in 1979) can be summarized as follows:

<u>Shin</u>	<u>Award to Delivery (Months)</u>
USS NIMITZ (CVN 68)	97 (Actual)
USS DWIGHT D.EISENHOWER (CVN 69)	93 (Actual)
USS CARL VINSON (CVN 70)	95.5 (Predicted)

CVN 68-70 were constructed by NNS in its South Yard, using a 310 ton capacity gantry crane, for structural sub-assembly erection and machinery lifts. This crane, which at the time was the largest in this country, serviced Shipways 10 and 11 where all three ships were erected. In 1973, construction was started on a new shipyard for commercial work. This was located on filled land just north of the existing facility and was completed in 1976. The new facility consisted of a building basin (Shipway 12), a subassembly area adjacent to the building basin which was sewed

by 60 and 200 ton cranes, a 900 ton gantry crane spanning both the building basin and the subassembly area and a large steel production building containing a panel shop, several steel assembly areas, two outfitting berths, and cutting and forming equipment, all supported by its own steel storage and surface preparation complex. This new facility, which was built for construction of commercial LNG and ULCC ships, offered some obvious advantages for construction of a comparably sized nuclear carrier. The use of this facility, in light of the uncertainties of the domestic commercial shipbuilding market, was studied by NNS and its potential advantages evaluated. Based on this evaluation of historical data NNS proposed a 96 month period from contract award to ship delivery for CVN 71.

Schedule Studies

During this time the Navy was also studying internal schedule proposals ranging from 60 to 96 months in order to determine what economic benefits could be achieved, what long lead time material would have to be purchased and what work arounds or other techniques might be necessary if a shorter construction period were to be achieved. Other studies examined manpower limitations, the potential for farmout of all or part of the structural

subassemblies, the NNS business environment and the negotiation strategies and format for introduction of an early delivery incentive. A number of conclusions were reached early in this study process:

- * The use of farmout for substantial quantities of structural subassembly fabrication was disruptive and not cost effective.
- * The time required by the appropriation process to obtain appropriate funds for long lead time material precluded any schedule shorter than 74-77 months from award of the long lead time contract to ship delivery (even this schedule required work-around for some critical machinery components).
- * It would probably not be feasible to negotiate an early delivery incentive, or a significantly earlier delivery than that proposed by NNS, until future NNS workload considerations were solidified.

Based on these conclusions it was determined that Navy efforts should be concentrated on enabling the feasibility of a 77 month

building schedule. The initial step was the issuance of the long lead time material procurement and engineering contract between NNS and the Navy on May 5, 1980 in which a planning date of October 1986 for ship delivery was specified. The long lead time material contract required that, where possible, procurements should support the October 1986 date despite the ship construction contract proposal for a 91 month schedule(December 1987 ship delivery) proposed by NNS in July 1980. This involved expediting, and potentially storing, approximately 150' major machinery and material purchase orders being placed by NNS and a comparable number of GFM procurements. Considerable financial risk was involved, but the potential cost savings of earlier ship delivery made that risk justifiable, and the cost of storing material would be offset by savings resulting from early order placement.

Providing Incentives

A definitized contract was executed on September 30, 1980 that specified a September 1987 ship delivery date. On March 4, 1981 a contract modification to add a complex passive protection system to the ship was bilaterally negotiated. This contract modification further complicated the schedule issue by adding significantly to both the scope of work and technical risk of early structural

erection and resulted in a five month addition to the contract ship delivery schedule.

Throughout this time both the Navy and NNS continued to expedite material deliveries in order to support an October 1986 ship delivery and studies continued to address its feasibility. As the Navy's confidence in GFE and CFE deliveries increased the prospects for a shorter construction period improved. The potential cost savings being projected for a 1986 ship delivery were clearly sufficient to support the offering of additional incentives. The Navy estimated that fixed costs alone during a fourteen month schedule reduction would amount to \$ 42 million, and savings from avoiding inflation increases during that period could amount to over \$ 50 million as well. What the Navy and the shipbuilder needed to make the shared commitment was an incentive to balance the technical risks of schedule compression with the cost savings potential to the Navy and profit increases for the shipbuilder. The Navy held all risks for escalation costs under the contract terms. The shipbuilder and the Navy would share other cost savings (or growth) according to incentive provisions of the contract. The shipbuilder had to assess the value of his share of the cost savings against the schedule risks and facility commitment required to attain the earlier schedule. The major

break came about when a combination of business factors provided the incentive to NNS to accept the risks associated with schedule compression. These factors included:

- * The absence of commercial workload for the new North yard. This permitted utilization of Shipway 12 with its associated sub-assembly area and 900 ton gantry crane, as well as the new steel fabrication shop, for aircraft carrier construction.
- * The potential for series production of CVN's resulting from Congressional consideration of a proposed two ship fully funded program for construction of CVN 72 and 73, which would provide a stable workload base for many years to come. There was additional value to compressing the CVN 71 schedule, since CVN 72 and 73 escalation costs would be significantly reduced by an earlier start in sequence with CVN 71 and these cost savings enhanced the possibility of Congressional approval of the two ship program.
- * An Incentive for Early Delivery clause was signed on December 3, 1981 which provided for payment of an *additional profit of \$50,000 per day, to a maximum of

\$21,000,000 for a 14 month earlier delivery, if the shipbuilder could achieve schedule compression. This was to be in addition to the share line savings, if any, that would be split under the terms of the Fixed Price Incentive Fee (FPIF) construction contract. The Navy's saving would exceed the maximum amount of the incentive payment, realizing a saving to the taxpayer, in addition to earlier delivery of the ship. And, if earlier delivery were not achieved, the basic contract terms would prevail, with no incentive paid. In this combination of results, the incentive clause established the boundaries of risk and reward for both the Navy and the shipbuilder and formed the basis for the sustained commitment needed to make the goal a reality.

This background information is provided in order to make a crucial point. The manufacturing improvements that are possible, and which will be described in this paper, will not generally be applied unless there is recognition of the fact that both the owner and builder must have an incentive for their use, and that extensive long range planning must be done to determine their most economic application and support that application with early

material procurement. An additional factor that must be considered is the stability of the construction baseline. Extensive advance planning is useless if the baseline design is subject to extensive change. The customer must decide what he wants early in the game and then stick to it. Changes are always disruptive, but they can be much more disruptive if the shipbuilder has done extensive planning for on block outfitting and work grouping. The CVN's are a mature program that has been well defined by the experience with the earlier ships of the class and the Navy has been actively resisting the "newer is better" syndrome. by severely limiting changes.

Construction Methods

The superlift ability of the 900 ton gantry permitted construction of much larger subassemblies in the steel fabrication shop and platen area. The shipbuilder made extensive use of Computer Aided Design/Computer Aided Manufacturing (CAD/CAM) to plan subassembly module sizes, cut steel and provide control over the manufacturing process in order to achieve the tolerances necessary for orderly assembly. These subassemblies were heavily preoutfitted on block and in many instances were virtually complete when lifted into the building dock. Inner bottom sections

were piped out and painted and the rate of tonnage buildup in the dock shown in the following chart reflects the impact of this preoutfitting as well as the effect of the productivity improvements resulting from efficient on block construction. With the increase in the amount of work being done on the platen NNS was able to significantly increase the percentage of down hand and automatic welding, with concomitant reductions in skill level requirements and weld reject rates. Although statistical evidence is not yet available, the improvement in the work environment should improve product quality and worker safety. In support of the early outfitting- the Navy agreed to a two tier system of delivery dates for GFM. In addition to the Shipbuilder Desired Dates (SDD's) agreed to by the contract a series of Preferred Dates (PSDD's) were established for early delivery of material to permit the maximum degree of preoutfitting. These dates were provided by NNS to the Navy very early in the process so that the response provided could be incorporated into the planning process. Wherever possible, the Navy met the PSDD and, when it could not, it provided the best possible projections so that non-disruptive work-arounds could be developed.

Effect of Improved Methods

On the basis of the procurement planning accomplished and incentives provided NNS issued a key event schedule on January 8, 1982 that established September 1986 as a "work-to" delivery date and December 29, 1986 as a contract required delivery date. That schedule reflects the advantages of the modern steel erection facilities and superlift capabilities of the North yard and shows significant time savings in both the contract award to keel laying and keel to launch periods where prefabrication and rapid steel erection will provide maximum benefit. The following Table compares the schedule with that of CVN 70. It is worth noting that the launch to delivery period of a complex combatant ship is generally controlled by system testing and is not subject to similar schedule compression.

<u>Shin</u>	<u>Award</u>	<u>Keel</u>	<u>Launch</u>	<u>Delivery</u>
CVN 70	4/05/74	10/11/75	3/15/80	2/26/82
CVN 71	9/30/80	10/31/81	12/01/84	12/29/86

CVN 71 was launched on 28 October 1984, 16 months ahead of the original schedule and, as a comparison of the tonnage at launch

CVN 71 VS CVN 70 TONS OF SHIP IN DRY DOCK

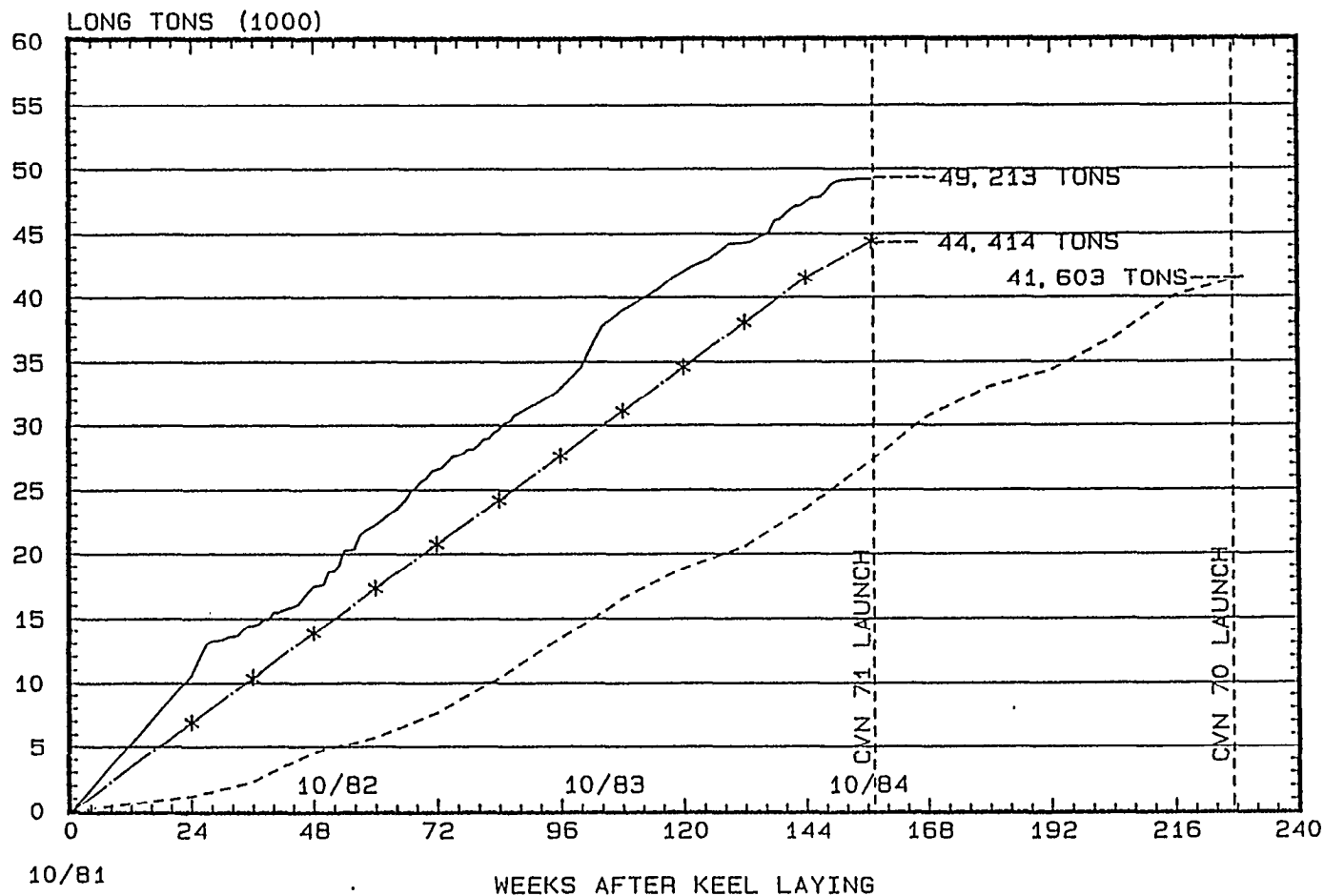
DATA AS OF 27 OCTOBER 1984 (WEEK 157)

CVN 70
ACTUAL

CVN 71
PLANNED

CVN 71
ACTUAL

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will show, much more complete. The extent of the change from building dock to platen construction can be seen from the fact that only approximately 160 modules were used to erect the entire CVN 71 structure. By comparison, a single typical innerbottom section on CVN 70 that required 58 subassemblies was assembled from only 12 subassemblies on CVN 71. It is still too early to fully assess the impact of these changes in the CVN construction process on issues other than schedule, where it is apparent that major improvements have been made and significant taxpayer savings will result. Productivity should be improved, particularly as improved familiarity with the processes impacts on CVN 72 and 73. One intangible fringe benefit has been the experience of seeing some rather spectacular module lifts, some examples of which are provided by the following photos, which show the keel laying, bow section lift and the entire island structure being lifted as a single module.

Conclusions

Much has been accomplished by this cooperative Navy/NNS effort and much more needs to be accomplished. There should be recognition of the need for improved planning in this area from inception of ship concept definition so that contract designs

consider the needs of the new processes available and financial and contractual planning support the technical path chosen. Incentives must be provided and a stable workload attained. The potential benefits to the American taxpayer and shipbuilding industry profitability are enormous. That much more can be done can be seen by looking at the progress being made on ABRAHAM LINCOLN (CVN 72). Its keel was laid in Shipway 12 on November 3, 1984 (5 days after the CVN 71 was launched) and 16 weeks later there were 10939 tons of ship erected in the shipway and massive amounts of subassembly work complete on the platens. By comparison, at this same point in time on CVN 70 and 71 we have estimated that there were 801 and 7818 tons of ship respectively in the shipway. There are parallel gains waiting to be recognized and achieved in other programs if the Navy and the shipbuilding industry strive together to define and achieve them.

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